Come Closer: Encouraging Collaborative Behaviour in a Multimedia Environment

Cliff Randell[1], Anthony Rowe[2]

[1]Department of Computer Science, University of Bristol, UK
cliff@cs.bris.ac.uk
[2]Interactive Media, Arts Institute Bournemouth, U.K. and Squidsoup
arowe@aib.ac.uk / ant@squidsoup.org

Abstract. Come Closer describes a combined research and art installation using wearable technology and collaborative interaction to explore and challenge the sense of personal space and proximity to others. Participants become acutely aware of each other; aware of their presence in both physical and virtual space. They are encouraged to probe and investigate the boundaries that define personal space, to test them and to cross them. Interaction is defined entirely by position in a room, and the distances between them and others. The movements of the participants are logged and analysed for expected and unexpected behaviours.

1 Introduction

In this paper we present an interactive art installation designed to encourage participants, or players, to overcome traditional notions of personal space in a public area. Edward Hall first identified the concept of proxemics, or personal spaces in his book, The Hidden Dimension [1]. He describes the subjective dimensions that surround someone and the physical distances one tries to keep away from other people according to subtle cultural rules. This project provides an exploration of ways in which an interactive art installation can break down these inbuilt restraints, or inhibitions.

The name Come Closer draws on the locative element of the project, combined with notions of shared experience and collaborative space. The closer people get to each other, the more acutely aware of each others presence they become. This may be playful, comforting or disquieting. With more people in a room, complex relationships and harmonies can begin to form and disappear, allowing scope for cooperation and confrontation, intimacy and rejection. It also allows people to begin to play the space in collaborative and creative ways.

In an immersive experience dominated by sound and digital projection, conscious awareness of the physical presence of others diminishes as participants focus instead on the virtual. However, if the virtual space works as a mirror on reality, with each person represented in the virtual space, awareness of others begins to return. If representations in the virtual space are affected by the proximity of other people, and if things begin to happen when participants approach

each other, this should have an effect on the behaviour of those using the space, and their behaviour can to an extent be controlled - or at least encouraged in certain directions. We know how space is supposed to unfold before us when we move through it - sonically as well as visually. When these relationships are altered, connected in new and different ways, we become acutely aware of them and try to rationalise the changes. The effects can be unnerving yet ultimately rewarding as we master the new relationships and make them work for us in creative ways.

The notion of shared experience is central to the project, and this needs to work at the crossover between virtual and real. A wall projection is used as a virtual mirror; movement in real space is seen in the reflection - an abstracted mirror image of the real space.

We first describe the installation and its development, then present subjective comments from the participants with our observations, followed by an objective analysis of the logged movements and interaction, and lastly present our conclusions and thoughts for future work.

2 The Installation

There have been several phases in the development of the installation and these provide the background to the concepts and thinking that led to Come Closer (2005).

2.1 Background and Earlier Work

Squidsoup, the creative developers of Come Closer, have a history of creating works that explore the possibilities of creative interaction. Come Closer builds on their experience in this field; projects such as Alt-space [2], Ghosts [3] and Freq [4] deal with the relationship and interfaces between people and virtual spaces in a range of guises.

Come Closer is most closely related to their ongoing Altzero project [5], particularly in the use of physical and virtual space to dissect and explore sound and spatial musical composition. In early 2001, altzero2 was premiered at the ICA, London, U.K. The piece looked at the possibilities of navigating through a piece of music composed in virtual space. It used a 3.5m x 3.5m semi-enclosed active square to control movement through a virtual space projected on a single wall; position tracking was achieved using a single camera. Standing forward made the square, which was transposed into an infinite virtual space, move forwards. Standing on the left made the square bank left, and so on. As participants move through the virtual space, they see and hear what is in proximity to them, so movement equates to exploring the spatialised musical composition.

The piece was effective as an immersive experience, and also as a means of experiencing and navigating through a piece of music, but was less successful in dealing with collaboration in virtual space, as people were generally unaware of how the piece worked when multiple participants were involved. Direct user

feedback was blurred with several people in the space simultaneously attempting to control the direction of virtual flight. If a second person walked into the space (the first person may be unaware of this), the direction of movement changed as it was now controlled by the average of two people's positions rather than the direct relationship with a single user.

Another reason was also suspected for this confusion: we observed that if two people are in an enclosed area they will naturally, and subconsciously, gravitate to opposite corners of the space. This notion of encroaching on others personal space was the primary inspiration for developing Come Closer.

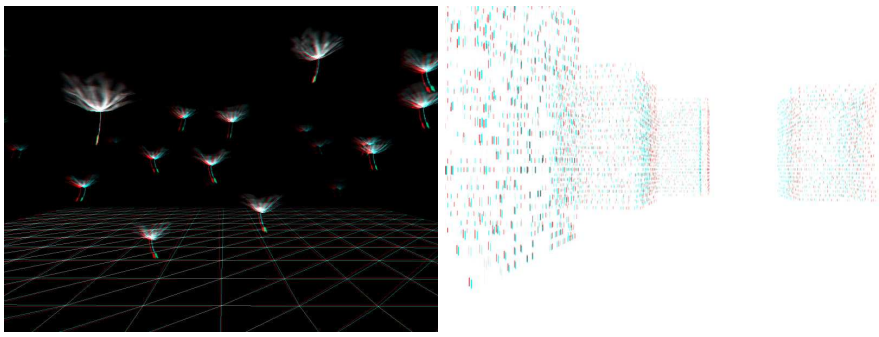
2.2 Initial Research and Trials

The Come Closer project started with further dissection of this problem. It was felt that we might overcome the confusion if the position detection system was sufficiently accurate and responsive, and opted to use an ultrasonic position detection system designed by the University of Bristol [6] with hardware developed by HPLabs, Europe [7]. This used a head-mounted transducer connected to a belt-worn networked PDA.

Initial experiments were carried out with a design identical to Altzero2 in terms of user interaction: multiple participants collaboratively controlling movement through an infinite virtual space through their position in a shared physical space. The environment was semi-abstract and immersive, consisting of randomly placed virtual floating dandelion seeds, using anaglyphic stereoscopy to enhance depth perception (see Figure 1a). This approach showed that the problems were not to do with accuracy or responsiveness. Participants need direct and immediate audiovisual responses to their own interactions taking an average of all positions results in a lack of clarity and personal connection with the piece.

It was only by altering the relationship between the physical and virtual spaces that the combination of results we were searching for could be achieved: shared audiovisual experience, direct one-to-one feedback, collaborative interactivity and an uninhibited awareness of others in both the physical and virtual spaces. The viewpoint of the projection was thus altered to become an abstracted mirror image of the physical space - a static virtual camera in a moving space, rather than the converse. Each person would see an iteration of themselves (and others) on the screen, and the audiovisual experience could then be controlled directly from the distances between participants.

Two virtual spaces were created for public presentation and reaction. The first was a simple space containing up to four elongated cascading towers (or columns - see Figure 1b). Each tower represented one participant, its position in the projected space reflecting the participants position in the real space. Sound consisted of a series of sine waves whose frequency related to the distance between each pair of people. The second space was an adaptation of the dandelion seeds but, whereas before the seeds were static and participants moved through the space, in this incarnation the seeds and people moved, but the virtual view was static. By moving, participants generated virtual wind and gusts of air



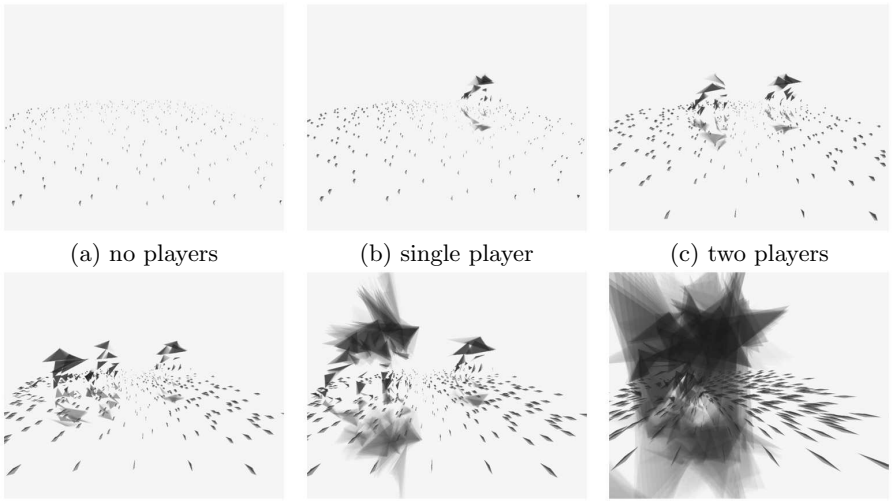
(a) (b)

Fig. 1. Early versions a) Dandelions and b) Columns

that pushed the seeds around. Sound, as before, was emitted by the seeds as they were pushed out of the visible area. An undulating surface was added to the floor of the virtual space that bulged wherever the participants were to indicate their position. Both spaces were audiovisual trials to explore the levels of complexity that can be entertained in such a setup. Responses from the trials were very positive people generally understood the connection between what they did and what they saw; opinions on which version (simple interaction with the columns against more abstracted link between cause and effect with the dandelions) were varied. Several hundred visitors took part in the trials, of which some 137 contributed comments including the following:

"Really enjoyed the columns version as it was clear what effect my position and movement was having; the link with 'your' column was strangely endearing and made me feel part of the art; found the 'columns' easier to unravel quickly; really enjoyed the experience and finding out how it reacts to your movement/group movement; feeling of control over intangible things; I liked experimenting with new movements (swinging yourself around with someone else); you felt part of a performance; artistically and psychologically interesting - e.g exploring sensations of personal space, racial difference; bit freaky - tried to avoid people as much as possible; interesting to watch the way people explore in this new environment and how they create(?) or remain more stationary this from a psychologist's perspective with obvious interest in the potential information to be gathered in this forum; fascinating and positively weird - I liked wandering while watching - circling each other etc; liked the dandelion seed but not so sure about the other one."

In order to complete the process, however, a new audiovisual experience was needed that would properly use the collaborative techniques developed. Additionally, a bespoke ultrasonic system needed to be developed. In its current state it was over-complex, cumbersome for the user (relying on handheld devices) and erratic. A new ultrasonic tracking system was devised based on another University of Bristol design [8] enhanced with RF synchronisation giving approximately



(a) no players (b) single player (c) two players

(d) three players apart (e) three players together (f) four players together

Fig. 2. Come Closer (2005) - screengrabs

5cm accuracy at 3Hz with transponders fitted into baseball caps. Designed for four simultaneous players, this system was easy to use and did not rely on the wireless networking of the previous design.

2.3 The Final Version - Come Closer (2005)

Visually, the final version is an abstract representation of the position and movement of people in virtual space; as the virtual space is a reflection of the real space and the position of participants in it, the projection acts as a mirror (see Figure 2). Similarly, the sounds are designed to highlight the spatial relationship between participants. Each person has a threshold - a personal space that, once encroached upon, triggers clusters of MIDI piano notes. The more people enter into each others personal space, the more complex the note clusters.

In trials it was readily apparent that, once participants had understood this process, they began to play with and explore these boundaries, getting much closer to each other than in previous experiments and even forgetting (albeit temporarily) their own standards of personal space (see Figure 3). Analysis of user feedback seems to confirm our hopes that people generally understood more of the systems in place, and appreciated the ability of the piece to let people assign their own meaning to the experience (like playing windchimes, underwater sonata etc).

The final version of Come Closer was premiered at Lovebytes 06 in Sheffield, U.K. Around 150 people participated and provided feedback; all positional data was also recorded for subsequent analysis. The feedback and analysis are presented and discussed in the following section.

(a) (b)

Fig. 3. Come Closer (2005) - player interaction

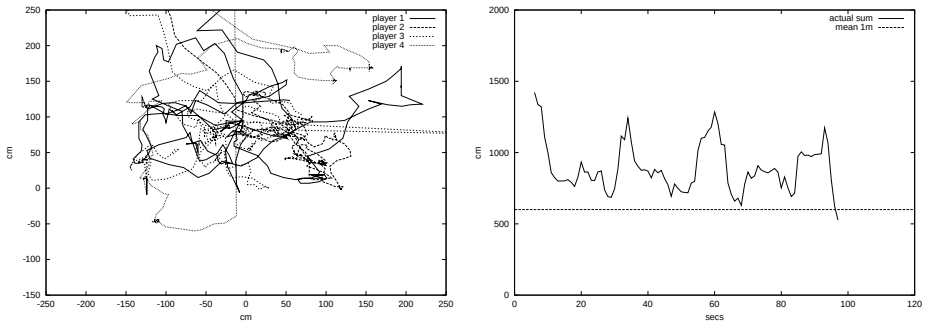
3 Feedback and Behavioural Observations

3.1 Audience Feedback

Again, participants were invited to leave comments on their subjective experience of the installation. These were generally positive and provided support for our aspirations. 34 responses were obtained and an edited selection is given here:

"Mysterious; Strange; Nice, I like the tracking technology. Needs more sound. Good! Great fun - would love to do with more people; Great. More sound and bigger room would be good, but good stuff! Encourages people to go against instinct to move away - beautiful images; Interesting to see the consideration of multi-user interaction; Wondering what kind of movements create the sound. Different; Confusing, made my eyes go weird; Fun; Like Satie but with better headgear; Very interesting - a great interactive experiment; Very very interesting. Playful, immersive . Beautiful; Impressive; Very good, intriguing; Good shapes; Trippy - scary applications??; Very good, funny; V. delicate + moving piece; Brilliant, interesting; Fantastic; Inspiring; Got a lot from visuals - not as much from sound (I understood this was because I was alone); Felt very playful; Like a dancefloor; Fantastic; Moving space; Really cool. So much you could do with this idea!; Wow! A visible approach to the effects of inter/intra personal dynamics, BRAVO!; It truly was an audio representation of the relationship between myself and one of my peers."

From the comments it is clear that many of the participants clearly understood the nature and purpose of the installation, and thoroughly enjoyed participating. Interestingly, some players commented on the dynamic aspects of the piece with comparisons to a dancefloor, and to the playful elements of the installation. This was also reflected in the recorded data as described in the data analysis.



(a) (b)

Fig. 4. Typical results plots (a) path and (b) proximity

3.2 Data Analysis

Data was recorded during two 6 hour sessions. From these, fifteen 4 person interactions lasting over one minute were identified with an average session lasting 2min 52secs. Participants were briefed of the nature of interaction to be expected - that the display would change according to their position in the room, and that the musical effects would increase as they 'came closer' together. Thus they were anticipating the nature of the intended effects, but nevertheless a learning, or calibration, stage was expected.

We observed that in over 65% of the tests people would initially move together within 20 seconds of starting the experience. Others were more hesitant and could take 40 seconds or more to gain an initial impression. This could be regarded as the calibration stage. The nature of learning how to interact with the display and sounds incorporated direct reinforcement through spatial correspondence; self-administered awareness of the immediate interaction; as well as observation of the effects of the other participants moving around the floor-space. Other than the initial instruction there was no element of being taught how to use the installation.

The data collected from the installation was analysed graphically in three ways. Firstly, all periods when the full four players were present for over one minute were identified and the relevant log data extracted. This was then used to create, firstly, a real time 'movie' overview of the players movements; secondly, a 2D plan view showing the cumulative tracks of the players was plotted (e.g. see Figure 4a); and, lastly, a plot of the total 'closeness' - or proximity - of the players was made against time for each of these periods (e.g. see Figure 4b). A total of fifteen of these periods taken over the two days were plotted.

From the movies, typical behaviours included:

Hovering - standing in one spot and slowly moving around. This would be typical behaviour in an art gallery as a visitor stands relatively still and looks at an exhibit. This pattern was noted in over 80% of the tests.

Grouping - moving together, and then apart, in a regular cycle. This was the behaviour we anticipated from the design of the installation and was observed in over 65% of the tests. However the cyclical pattern was a surprise and is further analysed below.

Coupling - moving around in pairs, often two pairs. Again this would be normal behaviour at a conventional art installation where couples were visiting together. Observed in 40% of the tests. This was reinforced by the couples moving, as well as standing, together.

Circling - walking round the perimeter of the installation, often several times. In over 45% of the tests we observed participants moving around the edges of the floor-space, presumably exploring the limitations of the installation. This behaviour appears instinctive and, with hindsight, would seem predictable though it did not correspond with any significant display or audio effects.

From the proximity plots we observed a distinct pattern in which the players converged, and then diverged, and then converged again repeatedly. Eight of the periods were suitable for objective analysis of this phenomenon and we found a mean period of 34 seconds with a standard deviation of 11.5 seconds. This behaviour was completely unexpected and seemed to resemble some form of instinctive group dance inspired by the piece.

Applying Hall's analysis [1] for Americans to the measured distances between the players, we observe that players are moving closer together than the expected 1.2-3.5m associated with *social* interactions among acquaintances. The under 1.2m *personal* distance represents interactions typically found among good friends. According to research by Michael Watson, these distances are also likely to be appropriate for English players [9]. Therefore this indicates that Come Closer was successful in bringing players closer together than would normally be expected in a social environment.

4 Conclusions and Future Work

Come Closer (2005) has shown that it is possible to overcome traditional inhibitions of gallery visitors with multimedia interaction, resulting in an engaging experience where visitors begin to lose, albeit temporarily, their reservations and feelings of personal space. As well as predicted behaviour, unexpected movement patterns have been identified which indicate that it may be possible to initiate group, and individual, behaviours with suitably designed interactive multimedia displays.

Further experiments in a more controlled environment could enable a more detailed analysis, perhaps using principal components analysis, or even Felicific calculus [10]. It may be worthwhile to preselect the participants to explore different age, gender and cultural representations; and also to examine the influence of prior acquaintance. Controlled experiments with such groups could also focus on the relative influence of the visuals and audio components of the installation. However by using a controlled environment we risk losing the instinctive responses of the players. The design of further installations is thus anticipated building on the experiences gained from the development of Come Closer, with the prospect of learning more about how people interact with multimedia art.

5 Acknowledgements

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